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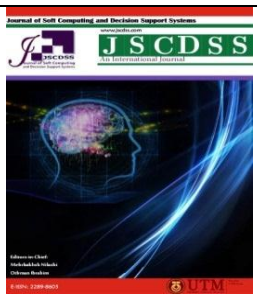

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The Status Quo and the Prospect of Green IT and Green IS: A Systematic Literature Review

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Abstract

The research on the relationship between environmental sustainability, Information Technology, and Information Systems under the terms of Green IT and Green IS has grown exponentially during the last five years specifically in IS research community. We have applied the systematic literature review to understand and summarize the existing research related to the field with the aim of understating better the research field, categorizing the studies and identifying some research opportunities and gaps for future research. Our systematic literature review highlighted the need of research in some topics. This review summarizes the state of available information related to Green IT and Green IS studies.

Keywords: Sustainability, Green, Information systems, Information technology, Green IT, Green IS, Systematic literature review

1. Introduction

There has been an increasing concern regarding environmental sustainability issues (Standing and Jackson, 2007), and recently has risen to "prominence as a solution to serious environmental and social problems"(Chen et al., 2008). Moreover, organizations and businesses are under an overwhelming pressure from their shareholders and legislatives to improve their environmental sustainability activities (Melville, 2010, Butler, 2011a, Murugesan, 2008). This concern regarding the environment and climate is creating an impetus and ever increasing momentum which sometimes is referred as Green Movement. One of most cited definitions of sustainability is the one presented in World Commission on Environment and Development in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). A long-missing piece of the sustainability puzzle, ecological sustainability refers to ''the ability of one or more entities, either individually or collectively, to exist and thrive (either unchanged or in evolved forms) for lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems'' (Starik and Rands, 1995).

Information technologies can affect the natural environment through two broad categories named as first order and second order effects (Molla and Abareshi, 2012). The first order is referred to negative impact of IT production, use, and disposal on the environment. This perspective considers IT as part of the problem (Molla and Abareshi, 2012, Dedrick, 2010). So, making IT product, use, and disposal more environmental friendly and greener is referred as Green IT (Dedrick, 2010, Molla and Abareshi, 2012, Ryoo and Koo, 2013, Molla, 2013). The term Green IT "denotes all activities and efforts incorporating ecologically-friendly technologies and processes into the entire lifecycle of information and communication technology" (Hedwig et al., 2009). The second order effect refers to the positive impact of IT on the environment which considers IT as part of the solution. Hence, utilizing IT to make business processes and activities greener is known as IT for green or Green IS (Sarkis et al., 2013, Dedrick, 2010, Molla, 2013, Watson et al., 2010). As IS researchers, Brooks et al. (2012) defined Green IS in two ways: "as the initiatives to utilize IT infrastructure to change organizational processes and/or practices to improve energy efficiency and reduce the environmental impacts, and to introduce environmentally healthier products and/or services". Though, Green IT and Green IS are interrelated concepts, but they have their own focus and purposes.

Green IT and Green IS are emerging research areas in the field of Information Systems research. Accordingly, most of the IS related publications are about call for actions (e.g. Watson et al., 2010), introduction to the research and the teaching agendas (e.g. Sarkis et al., 2013, Dedrick, 2010), and a few studies focus on the adoption and diffusion (e.g. Bose and Luo, 2011, Butler, 2011a). However, there is no overview of the state of the art in

supporting information systems and technology in sustainability research and practice. Accordingly, there would be a much more time spending in finding the body of knowledge of many unrelated literature by researchers who are motivated to contribute to this topic.

The main objective of this paper was to define the status quo of environmental sustainability research in Information Systems community. Our motivation was to establish a general background to provide useful information for conservation policies, and to identify the largest gaps to be filled by future research. The need for summarizing the existing knowledge and the managerial implications and future research agendas are arising due to the proliferation of publications in these research areas. The purpose of this study is to provide a systematic literature review (SLR) on the different roles of IT on environmental sustainability known as Green IT and Green IS. Understanding better the field, classification of the research and defining the research gaps are the opportunities which are provided for future researchers through this study. It also provides opportunities and benefits for practitioners by providing them a short introduction and correct direction to an area that would benefit their business and solve their problems.

The paper is organized as follows. Section 2 introduces the method applied for this systematic review. The results of the review are presented in Section 3, the discussion on these results are provided in Section 4. The directions for future research are pointed out in Section 5, Section 6 finally states the conclusion and future work based on the findings of the study.

2. Methodology

A systematic literature review aims to present and evaluate the literature related to the research topic by utilizing a thorough and auditable methodology. We have adopted the methodology proposed by Kitchenham (2004) to reflect the trend of Green IT and Green IS research. The two primary objectives of this study are: to identify, classify, and summarize existing research on Green IT and Green IS; and to identify areas and opportunities for future research. Based on Kitchenham (2004), accomplishing systematic literature review involves several discrete activities which are categorized into three main phases named as (1) planning the review, (2) conducting the review, and (3) reporting the review.

The planning activity focuses on developing the review protocol and explains how the researchers are should work and interact to conduct the review. In this phase the controlled procedure to conduct the review is prescribed which includes identification of research questions, search strategy and evaluation of resources, inclusion and exclusion criteria, quality assessment of resources and the methods of analysis. The second phase executes the defined protocol in planning phase, while the explanation of final report is elaborated in the final phase. Fig.1 depicts the activities of each phase. They will be described thoroughly in the following subsections.

2.1 Identifying the Need

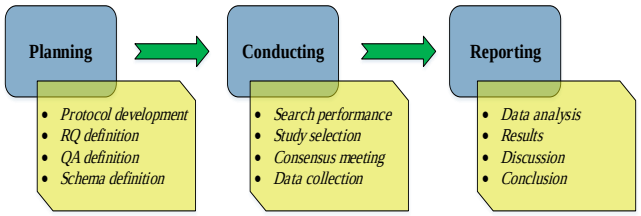

Fig. 1. Activities in systematic literature review.

The concept of environmental sustainability is grounded in the theory of Natural-Resource-Based View (Hart, 1995). He asserted that to enhance the environmental sustainability performance, three main objectives are must be considered: 1) pollution prevention, 2) product stewardship, and 3) sustainable development. To achieve these three goals Information Technology (IT) and Information Systems (IS) are of particular significance (Melville, 2010, Watson et al., 2010, Elliot, 2011). As discussed earlier, the effects of Information and Communication Technologies (ICT) on the environment (the negative and positive effects) are discussed by the IS community under the headings of Green IT (Green for IT) and Green IS (IT for Green). As a consequence of these newly defined topics in IS community, there is a growing number of studies in empirical and theoretical research, which it is pertinent to apply a systematic approach to assess and aggregate research outcomes in order to provide a balance and objective summary of research evidence to understand the status quo of the research topic and also to identify the research opportunities for further research which covers the objectives of the study respectively.

Therefore, we need to apply systematic literature review in sustainability aspects of IT and IS (Green IT and Green IS) to fulfill research objectives.

2.2 Research Questions

The research questions specifically addressed by this study are as follows:

- RQ1: What research has been conducted on Green IT and Green IS? Who has published, when and where (journal, conference)?

From answering this research question we intend to seek out and catalogue the existing research on this filed for the benefit of current and future research in this area.

- RQ2: What research questions have been covered?

We intend to understand what key subjects have been covered in these topics and record all answered key research questions.

- RQ3: What is the current state of Green IT and Green IS research?

We intend to categorize the future and open research streams on Green IT and Green IS from the findings of the selected studies for this systematic literature review.

2.3 Conduct the Review

In order to get a sense of the current state of Green IT and IS studies, we examined both academic journals and conference proceedings.

In terms of the academic journals, our review began with a search of seven premier IS academic journals named as: Management Information Systems Quarterly, Information Systems Research, Journal of Management Information Systems, Journal of the Association for Information Systems, Communications of ACM, European Journal of Information Systems, and Information Systems Journals. [*] However, as we found only five "issues and opinions" articles related to Green IS and Green IT in MIS Quarterly, we then expanded our search to other journals and conference proceedings. Specifically, following Levy and his colleague's (2006) suggestion we searched Journal of Strategic Information Systems, Journal of Information Technology, Journal of Computer Information Systems, Information Systems Research, Information Systems Frontier, Information and Management, Communications of the Association for Information Systems, Australian Journal of Information Systems, and Academy of Management Journal. The IS conferences to target were determined based on those that were supported by the Association of Information Systems (AIS) [†], which is the premier global organization for academics in Information Systems. Hence, the proceedings of the International Conference on Information Systems (ICIS), Hawaii International Conference on System Sciences (HICSS), American Conference on Information Systems (AMCIS), Australian Conference on Information Systems (ACIS), and Pacific Asia Conference on Information Systems (PACIS) were reviewed. Furthermore, additional studies from other journals or conferences were included if they were determined to be relevant and useful for our study.

First of all, the search keywords for conducting the review were selected. Since the selection of keywords is related to the quality of results, the general terms were selected with the aim of confirming that most of the related studies are included.

The final search stream has been selected after doing some pilot testing which consisted the following Boolean expression "*(A1* ***OR*** *A2* ***OR*** *A3* ***OR*** *A4)* ***AND*** *B* ***AND*** *(C1* ***OR*** *C2* ***OR*** *C3* ***OR*** *C4* ***OR*** *C5* ***OR*** *C6)*" where the search expressions are provided in Table 1.

Table 1
Search expressions.

A1. Information Technology	B. Green	C1. Environment
A2. IT		C2. Environmental
A3. Information Systems		C3. Environmentally
A4. IS		C4. Sustain
		C5. Sustainable
		C6. Sustainability

By the aim of defined search stream and through the selected journals and conferences, the search was carried out. Both the Microsoft Excel file together with Endnote which is a reference management software were used which helped us to manage the results.

2.4 Study Selection and the Inclusion and Exclusion Criteria

The selection of studies have been done through five phases which are outlined in Table 2. The purpose of this selection procedure was to identify and select the papers were matched the objectives of the systematic literature review. As the selected keywords for the search stream were too general, it was not expected that all the found papers were included. The Endnote reference manager helped the researchers to manage the duplicate references more efficiently and generate an integrated file.

Table 2
Inclusion phases.

Phase	Phase description
P1	Selection of studies based on the conducted search.
P2	Screening: inclusion based on the inclusion criteria.
P3	Screening: exclusion based on the exclusion criteria.
P4	Screening: exclusion based quality assessment criteria.
P5	Confirmation

The inclusion and exclusion criteria are used to ensure that just the relevant articles are included in the SLR process. The inclusion and exclusion criteria are presented in Table 3.

Table 3
Inclusion/exclusion criteria.

Inclusion criteria
• Directly or indirectly answer any one or more defined research questions.
• Focus on environmental sustainability through utilizing ICT.
• Was published in years: 2007-2013[‡].
Exclusion criteria
• In form of book and overhead presentation.
• External to IS research field.
• Papers when only abstract and no full text were available.
• Articles that did not match the inclusion criteria.

2.5 Quality Assessment

In the final set, each of the included papers has been assessed regarding their quality. This step has been done during the data extraction activity and was used to ensure that the included paper made a valuable contribution to the SLR.

To assess the quality of included papers, we have adopted the quality assessment criteria proposed by Dybå

[*] These seven journals are proposed as the top journals by senior scholars at the time of the review: http://aisnet.org/general/custom.asp?page=JournalRankings

[†] For further details, refer to the AIS website at: http://www.aisnet.org , last accessed December 10th, 2013.

[‡] 2007 has been selected as the base line because the topic was first introduced in IS community by Elliot in PACIS 2007 Proceedings.

and Dingsøyr (2008)*. These criteria are presented in Table 4. Based on Dybå and Dingsøyr (2008), these 11 criteria covers three main issues related to the quality of papers selected for this SLR as:

- *Rigor:* Has a thorough and appropriate approach been applied to key research methods in the study?
- *Credibility:* Are the findings well-presented and meaningful?
- *Relevance:* How useful are the findings to the IS research community?

Table 4
Quality assessment criteria (Dybå et al. 2008).

Quality threshold	
1.	Is the paper based on research (or is it merely a ‘‘lessons learned” report based on expert opinion)?
2.	Is there a clear statement of the aims of the research?
3.	Is there an adequate description of the context in which the research was carried out?
Rigor	
4.	Was the research design appropriate to address the aims of the research?
5.	Was the recruitment strategy appropriate to the aims of the research?
6.	Was there a control group with which to compare treatments?
7.	Was the data collected in a way that addressed the research issue?
8.	Was the data analysis sufficiently rigorous?
Credibility	
9.	Has the relationship between researcher and participants been considered to an adequate degree?
10.	Is there a clear statement of findings?
Relevance	
11.	Is the study of value for research or practice?

The first three criteria are the minimum quality threshold to exclude the papers which do not meet the objectives of the review. The five criteria (4-8) cover the issue of rigor which considers the applied research methodology, data collection tools and techniques, and also the trustworthiness of its findings. Criteria 9 and 10 are related to the credibility of the papers which assures the validity and meaningfulness of findings. And the final criteria (11) covers the relevance of the study to the IS research community.

2.6 Data Collection and Analysis

To collect the most relevant information from the selected papers a data collection form was designed in order to facilitate the process of analysing the compiled data. This form is presented in Table 5 which from now on is referred as data schema. The schema has been completed following the further review of selected studies by the researchers, then the agreement has been met on all the issues in the final collected data.

* These criteria are utilized in the context of Software Engineering. The changes have been applied to be applicable for IS research area.

3. Results

This section presents the results of the conducted systematic literature review. The purpose of this section is twofold. In one hand the analysis of results are stated, furthermore the quality evaluation of results are depicted.

Table 5
Data schema.

Basic information	It includes the title and the author(s) of the paper.
Publication	It refers to whether the publication is journal or conference proceeding.
Year	It refers to the publication year of the article.
Objectives	It refers to the objectives that the paper tries to fulfil.
Filed	It identifies the stream of the paper, whether it is related to Green IT or Green IS.
Focus	It deals with the focus of the paper. It focuses on initiation, benefit, adoption, or design and implementation.
Future work	It proposes the future work and the challenges related to the research questions.

3.1 Search Results

After the definition of the protocol, it was executed. First of all, the objective of selection process was to identify as much as relevant papers for the systematic literature review. As stated in Section 3.3, the search streams were too general which influenced the initial research results.

The approach of conducting the search and selection of related studies is shown in Fig.2. The initial search was conducted through the selected outlets by using the defined search stream explained previously. The initial search result returned us the total number of 198 publications including 46 journal articles and 152 related conference proceeding papers. After running the inclusion and exclusion criteria (see Table 3), 45 papers have been drop from the initial list comprising 11 dropped journal articles and 34 conference papers which resulted in a refined list of 153 papers. Then finally, by applying the quality assessment criteria and final confirmation of authors the list of included papers decreased to 32 journal articles and 112 conference proceeding papers.

The number of included studies per phase is showed in Fig.3. Furthermore, the included journal and conference studies categorized based on publish year are presented in Table 6 and 7. All the included articles are provided in Appendix A.

3.2 Quality Evaluation

The quality of the selected papers was tested by the utilization of a measurement instrument based on the defined criteria in Table 4 (see Appendix B). Each included study has been rated based on their quality threshold, rigor,

credibility, and relevance. Then, the measures of quality questions were discussed to out their degree of coverage. Figure 4 illustrated the coverage of different quality assessment categories for every included paper. As it is obvious almost all the papers had the threshold of quality to be included. It shows that relevance and rigor quality assessment criteria has more coverage. In contrast credibility has less coverage. All of the quality assessment criteria were covered at least 80% by Yes answers.

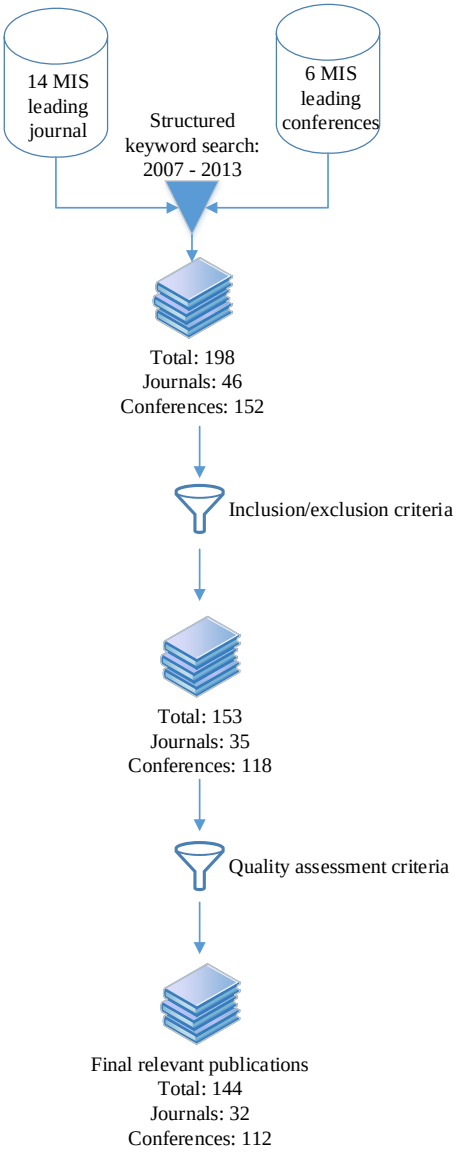

Fig.2. Publication collection method flow.

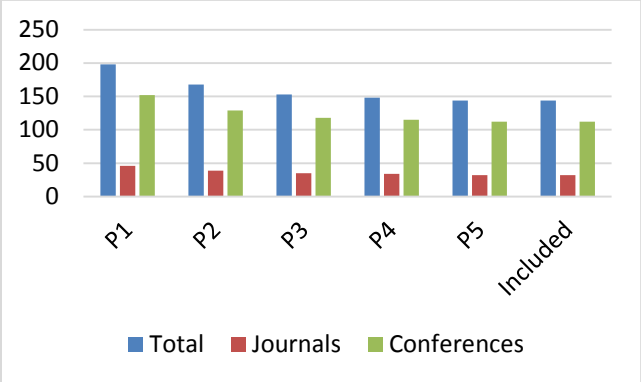

Fig.3. Studies included in the revision phase.

Table 6
Studies published in journals.

	MIS Leading Journals														
	AMJ	AJIS	CAIS	EJIS	IM	ISF	ISJ	ISR	JCIS	JIT	JMIS	JSIS	JAIS	MISQ	Total
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2009	0	1	0	0	0	0	0	0	2	0	0	0	0	0	
2010	0	2	1	0	0	0	0	0	1	0	0	0	0	2	
2011	0	0	1	0	0	0	0	0	0	0	0	9	0	1	
2012	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
2013	0	0	0	0	1	5	0	0	0	0	0	0	1	3	
Total	**0**	**3**	**3**	**0**	**1**	**5**	**0**	**0**	**4**	**0**	**0**	**9**	**1**	**6**	**32**

Table 7
Studies published in conference proceedings.

	MIS Leading Conferences						
	AMCIS	ACIS	ECIS	HICSS	ICIS	PACIS	Total
2007	0	0	0	0	0	1	
2008	0	2	0	0	0	1	
2009	3	2	1	1	2	3	
2010	10	0	2	2	2	2	
2011	9	1	4	1	4	4	
2012	15	0	4	1	11	3	
2013	10	0	1	2	0	8	
Total	**47**	**5**	**12**	**7**	**19**	**22**	**112**

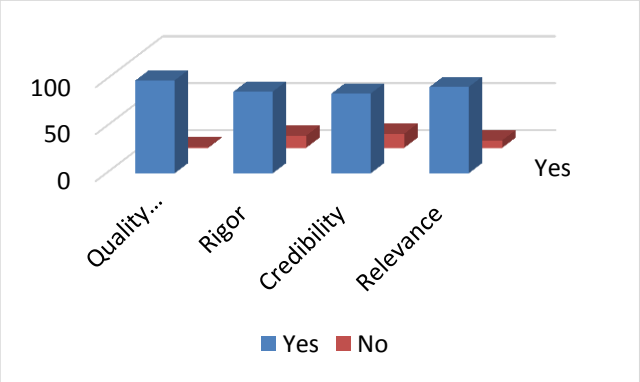

Fig.4. Quality assessment results for included papers and responses.

4. Discussion

In this section we will discuss the answers of the three research questions defined in section 2.2 as the target to fulfil the objectives of this review. Later, the weaknesses of this study will be pointed out.

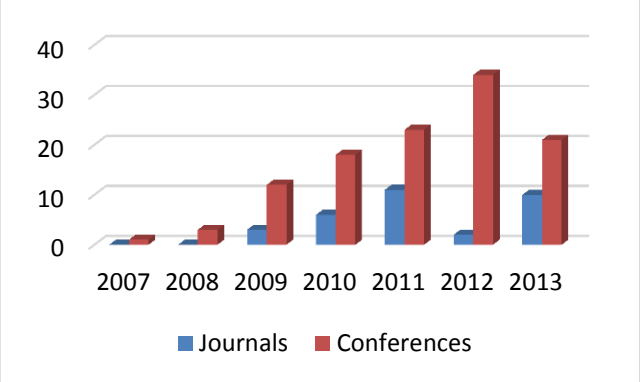

Fig. 5. Number of studies per year.

4.1 RQ1: What research has been conducted on Green IT and Green IS? Who has published, when and where (journal, conference)?

Overall we have identified 144 relevant papers (see Fig. 2): 32 journal publications and 112 conference papers. Table 6 and 7 provide an overview on journal and conference proceedings.

The earliest study in this area is a conference paper in PACIS 2007 proceedings while the first journal articles have been published in 2008, but this research area has been officially introduced to IS research community by Management Information Systems Quarterly (MIS Quarterly) in 2010/2011. Fig.5 shows the span of publications in these areas through 2007 to 2014 categorized by their type (journal - conference). As depicted in Fig.5, there is a total growing approach of publications in these areas. In conference proceeding publications the growing trend is continued from 2007 to 2012 while there is a short decrease in 2013. The reason for this fall is because of at the time of doing this review some studies are not published yet. Regarding the journal publications there is a pick in 2011 and it's because of the call for action and research by MIS Quarterly in 2010/2011.

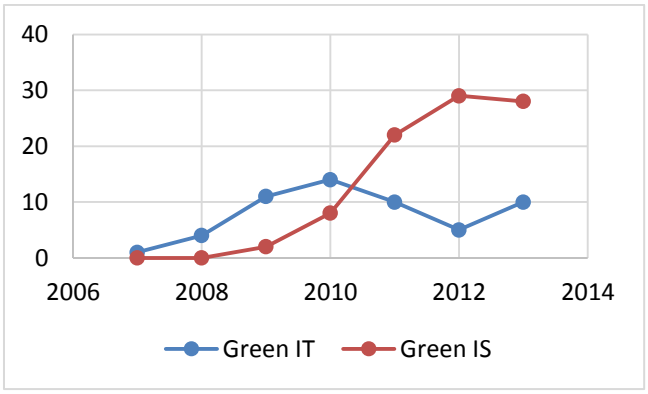

Fig.6. Number of publications in Green IT and Green IS from 2007 to 2014.

To understand the trend in each of these research areas (Green IT and Green IS), the identified publications have been categorized based on their focus (see Fig.6). As it's depicted in Fig.6, the term Green IT has been used widely and the quantity of publications has been increasing while there is peak of research in 2010/2011. However, the research trend on this topic has been declining because of the introduction of new research area named as Green IS in 2010/2011 by MIS Quarterly. For a quick illustration of focus of research in these publications we have generated a weighted topic cloud from keywords, extracted from title and abstract of included publications which is illustrated in Fig.7. As supported by Fig.7, the focuses of included papers are mostly on Green, Information Technology, Information Systems, sustainability and energy.

Fig. 7. Weighted focus cloud.

4.2 RQ2: What research questions have been covered?

In order to understand the studies that have been done on these topics, we have adopted the categorization

approach proposed by Califf et al. (2012)*. He asserts that the studies on Green IT and Green IS can be categorized into four groups named as "initiation", "design and implementation", "adoption", and "benefits". The studies related to initiation category are trying to answer the question "What is Green IT and/or Green IS?" Design and implementation embodies the practical utilization of Green IT and Green Is and answers the question "How Green IT or Green IS should be implemented and utilized?" Adoption studies contain the aspects of Green IT and/or Green IS acceptance and adoption and try to answer "What needs to be done for Green IT and/or Green IS to be adopted in different context?" And finally, the studies focus on benefits answer the question "How can Green IT and/or Green IS benefit environment, organization and stakeholders?"

The distribution of studies in these categories is illustrated in Fig.8. As depicted in Fig.8, the most portion of studies are first focused on the initiation of Green IT and Green IS with 44 studies out of total 144 publications (31%) and second is their benefit (with 28%) to environment, organization, and stakeholders. The third category of studies

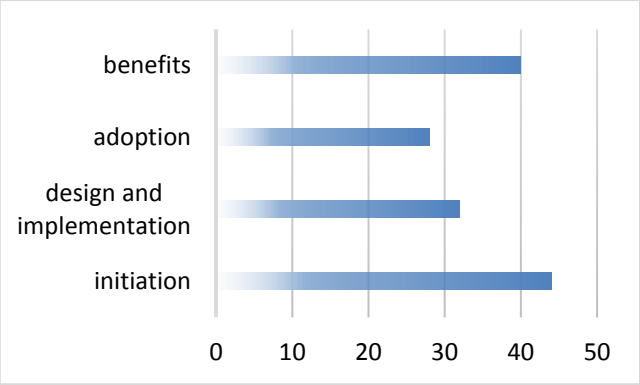

Fig. 8. Green IT and Green IS research categorization.

focus on design and implementation of Green IT&IS including 32 articles from 144 included papers, while there is a very few studies on their adoption with only 28 publications (19%).

What exactly Green IT and Green IS mean? How Green IT and Green IS can contribute to environmental sustainability? What are the Green IT and Green IS initiatives? What models and frameworks can be utilized to initiate Green IT and Green IS? There are some of the questions which are answered through initiation studies. Among 144 identified studies, 44 of them are trying to answer these questions. Some papers try to just introduce these newly defined research areas to academic and practitioners by introducing them the benefits of adopting Green IT and Green IS, defining the concepts and available research agendas (e.g. Bai and Sarkis, 2013, Sarkis et al., 2013, Dedrick, 2010, Watson et al., 2010, Beauchamp and Bowie, 1979). Some other studies propose or apply theories or frameworks to investigate the utilization of IS in different categories (e.g. organization, individual, environment, and technology) (e.g. Melville, 2010, Ryoo and Koo, 2013, Corbett, 2013, Dao et al., 2011). Some studies did reviewing literature on topics like environmental sustainability, energy informatics, Green IT and Green IS, and provided some conceptualizations, research agendas and contributions to body of the knowledge (e.g. Elliot, 2011, Loeser, 2013, Stolze et al., 2012, Jones, 1980).

The studies focus on the benefits of Green IT and Green IS talk about the benefits which are provided to organizations and environment through utilization and adoption of Green IT and Green IS initiatives and constructs the second largest proportion of studies on Green IT and Green IS with 28 percent of selected articles. In this category of studies, some scholars are focusing on reducing the energy consumption through utilization of Green IT and Green IS initiative (e.g. Corbett et al., 2010), some other studies focuses on utilizing the energy informatics and their impact on energy consumption behaviours (e.g. Yim, 2011, Corbett, 2013).

The design and implementation category of articles include 22 percent of all included papers for this SLR. Such topics include proposing approaches to monitor and measure carbon footprints and green performance of IT (e.g. Schödwell et al., 2013, Grimm et al., 2013), frameworks and models to implement Green IT and Green IS (e.g. Butler, 2011b, Schmidt et al., 2009) , and the approaches to makes business process management greener (e.g. Opitz et al., 2012).

The category which has the least portion of papers is the studies that focus on the adoption and diffusion of Green IT and Green IS initiatives. Only 28 articles out of 144 total included papers are grouped in this category. The Green IT and Green IS initiatives are adopted in two contexts: organizations and non-organization contexts. From the overall 28 adoption studies, 25 of them are in organization context while only three are in non-organization context (see Table 8).

Table 8
Green IT&IS adoption studies.

Context	
Organization	*Non-organization*
Chen et al. (2011), Chen et al. (2009), Corbett (2013), Jung et al. (2011), Molla (2013), Nedbal et al. (2011), Ryoo et al. (2011), Ryoo and Koo (2013), Seidel et al. (2010), Vykoukal (2010), Koo et al. (2013), Gholami et al. (2013), Wati and Koo (2012), Butler and Daly (2009), Kuo and Dick (2010a), Kuo and Dick (2010b), Molla (2008), Neuzil and Kovarik (1996), Molla and Abareshi (2012), Schmidt et al. (2010), Bose and Luo (2011), Benitez-Amado et al. (2010), Sacchero and Molla (2009), Perrow (1997), Lei and Ngai (2013)	Kranz and Picot (2012), Kranz and Picot (2011), O'Fallon and Butterfield (2005)

* The original categorization is for Energy Informatics (EI). We have adapted based on the purpose of our study.

To categorize the studies on the adoption of Green IT&IS in organizations we grouped them based on their levels of analysis. In practice, there are three levels of analysis in which the studies related to organizational behaviour* are analysed as individual, group, and organization as a whole (Bommer et al., 1987). The individual level (micro) focuses on the analysis of individual characteristics that are crucial to manage and understand the behaviour in organization such as personality and ability, values, moods, perceptions, attitudes and motivations. Related to organizational studies the effect of group or team (meso) characteristics and processes also need to be understood. Group is referred to as "two or more people who interact to achieve their goals" and team is defined as " a group in which members work together intensively and develop team specific routines to achieve a common group goal" (Bommer et al., 1987). A group can influence its members through different ways such as leadership, communication, and decision making.

Many studies also found that the characteristics of organization (macro) itself as a whole have important influence on the behaviour of its individuals and groups. For example, the values and beliefs of organization's culture can impact the behaviour of individuals. Furthermore, the organization's ethical behaviour can shape the behaviour and attitude of individuals and groups and thus influence their desire to work towards achieving the goals of the organization.

Overall, from the 25: 9 journal publications and 16 conference proceeding papers. These studies are categorized (see Fig. 9) based on their level of analysis and use of IT as a problem to be mitigated (Green IT) or as a solution (Green IS).

4.3 RQ3: What is the current state of Green IT and Green IS research?

This review summarizes the status quo of environmental sustainability issues associated with information systems and information technology. The harmonized data structure proposed in this paper and the cataloguing of Green IT and Green IS studies aim to facilitate the planning and integration of future assessments by showing what aspects have been covered and can be covered.

First of all, both academic journals and conference proceedings pay much attention to the introduction and initiation of Green IT and Green IS initiatives. As the potentiality of IT and IS towards ecological sustainability has been recently introduced and recognized by both practitioners and academic literature, it is obvious that most of the studies focused on the introduction of these research streams.

Secondly, scholars want to know what these new kinds of IT and IS can bring on board for businesses, and how these organizations can potentially benefit from different kinds of Green IT and Green IS initiatives. Given that Green IT and Green IS initiatives are relatively new, decision-makers need to justify why the organization should go with these initiatives. Therefore, the topic of benefits of Green IT and Green IS initiatives is the second major focus of academic literature.

Thirdly, the academic literature seems to relatively ignore the process of implementing Green IT and Green IS initiatives. It is justifiable, given that Green IT and Green IS initiatives are still new topics and there may be little information on these initiatives. However, whether or not firms can obtain the benefits of these initiatives largely depends on the degree to which these initiatives are successfully designed and implemented. From the previous studies on IT and IS, we know that investing on IT does not necessarily leads to benefit while organizations often fail to design and implement IT properly. Hence, we believe that this topic is important as the other two topics and needs the further attention of scholars.

Lastly, the adoption topic gained the least attention from the academic scholars. Although, the benefits of Green IT and Green IS initiatives are the main reasons for the firms to adopt these initiatives, other factors and motivations such as governmental pressures, stakeholder pressures, attitudes and beliefs towards Green IT and Green IS play an important role. Therefore, theoretical frameworks and models are needed to understand the factors that influence the adoption and initialization of these initiatives. We suggest that academic IS scholars are needed to focus more on this increasingly important topic.

4.4 Limitations of our study

Though this study has followed the methodology proposed by Kitchenham (2004) together with a predefined study protocol and a continuous interaction of authors, it has some limitations.

Firstly, although we have selected the journals and conferences that are directly related to IS studies, they are not comprehensive and therefore limit the work performed. A further improvement would be to include the outlets published by practitioners who are active in these fields together with expanding the search through the databases which are best fit to the field of Green IT and Green IS. Furthermore, to enhance the search process the snowballing approach proposed by Wohlin and Prikladnicki (2013) is recommended in which search process will continue from the included studies whether backward using their reference list or forward by looking for the papers that have cited them.

Moreover, in the selection procedure it was decided to include the only academic and complete-research papers. Including the research-in-progress papers together with the articles published by practitioners could help us to provide more insights together with more comprehensive results.

Lastly, the articles were evaluated by authors who rated them based on their knowledge following the defined schema. Although, the consensus meetings were arranged to peer review the articles, but the author bias is an

* "Organizational behaviour (OB) is the study of the many factors that have an impact on how people and groups act, think, feel, and respond to work and organizations, and how organizations respond to their environments" (Bommer et al., 1987).

associated risk, which would be avoided when assessing the contribution of each article.

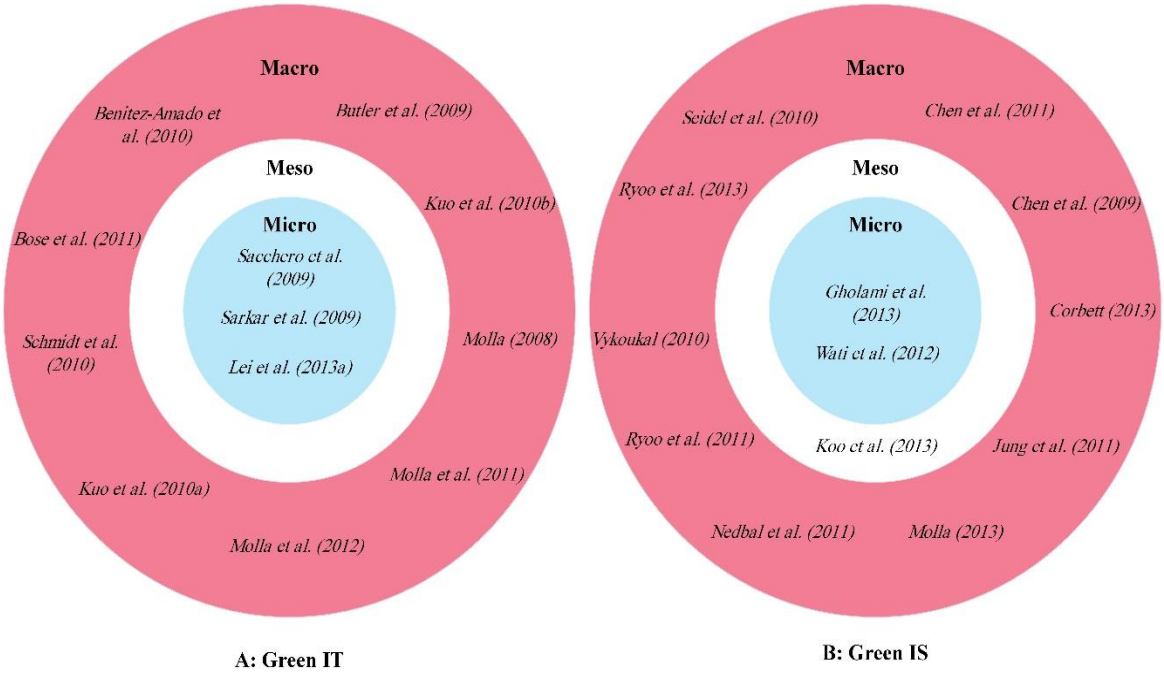

Fig. 9. Categorization of organizational Green IT/IS adoption studies based on level of analysis.

5. Recommendations for Future Research

Based on our review of academic journals and conference proceedings, we identify some of the important topics of interest in Green IT and Green IS that needs further investigation.

Firstly, we found a few studies that explicitly focused on Green IS in the selected outlets. Although, the number of studies on Green IS increased after the special issue by MIS quarterly in 2010/2011, but still there is a great portion of Green IT studies. Hence, our first recommendation for future researchers is to focus more on Green IS rather than Green IT, and specifically go beyond the IS infrastructure and study how it's initiatives can be used in business processes.

The topic which can be found in almost all reviewed articles is the necessity for the larger number of empirical studies. In such studies, it would be necessary to put into practice the proposals in socially and ecologically responsible organizations. In this approach, we would be able to know the results of usage and the main barriers, and obtain feedback from these organizations' needs. This type of study is called longitudinal in-depth study. Hence, in order to measure the environmental performance of the organization due to the utilization of Green IT and Green IS initiatives and to obtain their benefits, future researchers are recommended to put more effort on conducting longitudinal studies in these research streams.

Most of the studies on Green IT and Green IS are focused on their introduction and benefits while there is a dearth of research on their adoption in IS literature. Among the adoption studies of Green IS, few of them investigated the formation of the evaluation of Green IS and Green IT by organizational decision makers together with their intention to adopt these initiatives (see, Lei and Ngai, 2013, Gholami et al., 2013). More specifically, although there is a body of research investigating the adoption of Green IS in organizations, such research takes place primarily at the macro level where the organization itself is the unit of analysis. Hence, one of the prudent research questions for future studies concerning the adoption of Green IT/IS initiatives is:

What factors influence the managers' intention towards the adoption of Green IT/IS initiatives?

The pursuit of environmental sustainability should be the responsibility of everyone with different positions because of its complexity (Molla et al., 2014), while the urgency of the issues and the capacity of taking actions would be varied significantly. The adoption and implementation of organizational green initiatives is not solely driven by commercial imperatives (Hemingway and Maclagan, 2004), but it could be associated with the environmental beliefs and attitudes of managers as well. Knowledge regarding the environmental beliefs of managers and their actions towards environmental sustainability, together with the factors which contribute to their beliefs and action formation would be utilized to define the strategies to encourage individuals and groups to engage more in greener behaviours, and to facilitate the implementation of organizational Green IS initiatives and strategies (Molla et al., 2014). As such, the next research question to address is:

How the environmental values, beliefs, and norms influence the managers' proenvironmental behaviour towards the adoption of Green IT/IS initiatives?

In the literature it has already been suggested that information systems can play a meaningful role in altering individuals' beliefs towards the natural environment (Melville, 2010). In turn, these beliefs influence the behaviour of individuals, thereby including ecologically sustainable actions. However, to date it is unclear how to design and implement information systems that can influence the individuals' beliefs about the natural environment. In order to fill this gap, the future researchers are highly recommended to investigate:

How organizations can design and implement information systems that can alter the individuals' beliefs about the natural environment, and change their attitudes and beliefs towards sustainability transformation?

Finally, it is not promising that the adoption of Green IT/IS initiatives will be wholly beneficial for the firms. If the positive outcome is guaranteed for every adoption of these initiatives, there would be no necessary to argue on the values and benefits of adoption; every company would adopt every type of Green IT/IS initiatives with no hesitation. Considering the potential negative impact of these initiatives on the firm, we propose the final research question as:

What are the potential positive or negative impacts of Green IT/IS initiatives adoption on the firms' performance?

6. Conclusion

Green information technology and systems is a recent well-known topic in Information Systems research which has been the topic of academic and practitioners since 2007. Researchers in this field have addressed the issues related to environmental sustainability and the application of IT and IS.

This systematic literature review summarizes the status quo of research on these research streams. We analysed the studies with respect to defined research questions. This study contributes to research in several ways. First, it provides a systematic review of existing research in these areas. We have identified 144 significant contributions: 32 journal articles, and 112 conference proceedings. The contributions have been systematically categorized, which provides the current status of these emergent research fields and will ease researchers' search for relevant studies. Through this review we understood what research have been done and what research questions have been covered so far. Also, due to the vague understanding of these concepts, we conceptualized them based on the most cited definitions.

In spite of tackling several problems, some other issues still need to be addressed, such as application of different paradigms in studying these topics, the better understanding of association between information systems and environmental sustainability, to study how to design better information systems to benefit organizations' environmental sustainability, and to investigate the adoption of these initiatives in specific industries by considering multi cultures and regions.

Some directions for future research have been proposed to guidelines to cope with these limitations and shortcomings including conducting longitudinal in-depth studies, focusing more on micro-level as the unit of analysis, and including the influence of personal values and norms in investigating the adoption of these initiatives.

To conclude, to do this SLR we have applied the guidelines proposed by Kitchenham (2004), which made us confident in conducting our review thoroughly. However, the selection of keywords, inclusion and exclusion criteria are based on our judgment. We believe that this study can serve as a good foundation for those seeking to develop theories and broaden research in Green IT and Green IS.

Appendix A: Studies Included in the Review

Journal Publications

Bai, C., & Sarkis, J. (2013). Green information technology strategic justification and evaluation. *Information Systems Frontiers*, 1-17, doi:10.1007/s10796-013-9425-x.

Bengtsson, F., & Ågerfalk, P. J. (2011). Information technology as a change actant in sustainability innovation: Insights from Uppsala. *The Journal of Strategic Information Systems, 20*(1), 96-112, doi:http://dx.doi.org/10.1016/j.jsis.2010.09.007.

Benitez-Amado, J., Perez-Arostegui, M. N., & Javier, T.-T. (2010). INFORMATION TECHNOLOGY-ENABLED INNOVATIVENESS AND GREEN CAPABILITIES. [Article]. *Journal of Computer Information Systems, 51*(2), 87-96.

Berthon, P., & Donnellan, B. (2011). The Greening of IT: Paradox or promise? *The Journal of Strategic Information Systems, 20*(1), 3-5, doi:http://dx.doi.org/10.1016/j.jsis.2011.02.001.

Bose, R., & Luo, X. (2011). Integrative framework for assessing firms' potential to undertake Green IT initiatives via virtualization - A theoretical perspective. *J. Strateg. Inf. Syst., 20*(1), 38-54, doi:10.1016/j.jsis.2011.01.003.

Butler, T. (2011). Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS. *The Journal of Strategic Information Systems, 20*(1), 6-26, doi:http://dx.doi.org/10.1016/j.jsis.2010.09.006.

Cater-Steel, A., & Tan, W.-G. (2011). The Role of IT Service Management in Green IT. [Green IT, IT Infrastructure Library (ITIL), IT Service Management, sustainable computing.]. *Australasian Journal of Information Systems, 17*(1), 107-125.

Chen, A. J., Watson, R. T., Boudreau, M.-C., & Karahanna, E. (2011). An Institutional Perspective on the Adoption of Green IS & IT. *Australasian Journal of Information Systems, 17*(1), 23-45.

Chow, W. S., & Chen, Y. (2009). INTENDED BELIEF AND ACTUAL BEHAVIOR IN GREEN COMPUTING IN HONG KONG. [Article]. *Journal of Computer Information Systems, 50*(2), 136-141.

Corbett, J. (2013a). Designing and Using Carbon Management Systems to Promote Ecologically Responsible Behaviors. [Case Study]. *Journal of the Association for Information Systems, 14*, 339-378.

Corbett, J. (2013b). Using information systems to improve energy efficiency: Do smart meters make a difference? *Information Systems Frontiers*, 1-14, doi:10.1007/s10796-013-9414-0.

Dao, V., Langella, I., & Carbo, J. (2011). From green to sustainability: Information Technology and an integrated sustainability framework. *The Journal of Strategic Information Systems, 20*(1), 63-79, doi:http://dx.doi.org/10.1016/j.jsis.2011.01.002.

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Elliot, S. (2011). Transdisciplinary perspectives on environmental sustainability: a resource base and framework for IT-enabled business transformation. *MIS Q., 35*(1), 197-236.

Gholami, R., Sulaiman, A. B., Ramayah, T., & Molla, A. (2013). Senior managers' perception on green information systems (IS) adoption and environmental performance: Results from a field survey. *Information & Management, 50*(7), 431-438, doi:http://dx.doi.org/10.1016/j.im.2013.01.004.

Huang, A. H. (2009). A MODEL FOR ENVIRONMENTALLY SUSTAINABLE INFORMATION SYSTEMS DEVELOPMENT. [Article]. *Journal of Computer Information Systems, 49*(4), 114-121.

Kuo, B., & Dick, G. (2010). The greening of organisational IT: what makes a difference? [green IT]. *Australasian Journal of Information Systems, 16*(2), 81-92.

LOOCK, C.-M., STAAKE, T. & THIESSE, F. 2013. Motivating Energy-Efficient Behavior with Green IS: An Investigation of Goal Setting and the Role of Defaults. *Mis Quarterly*, 37.

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Molla, A. (2013). Identifying IT sustainability performance drivers: Instrument development and validation. *Information Systems Frontiers*, 1-19, doi:10.1007/s10796-013-9415-z.

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SEIDEL, S., RECKER, J. & VOM BROCKE, J. 2013. SENSEMAKING AND SUSTAINABLE PRACTICING: FUNCTIONAL AFFORDANCES OF INFORMATION SYSTEMS IN GREEN TRANSFORMATIONS. *Mis Quarterly*, 37.

Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information systems and environmentally sustainable development: energy informatics and new directions for the is community. *MIS Q., 34*(1), 23-38.

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BAI, C. & SARKIS, J. 2013. Green information technology strategic justification and evaluation. *Information Systems Frontiers*, 1-17.

BEAUCHAMP, T. L. & BOWIE, N. E. 1979. *Ethical theory and business*, Englewood Cliffs, NJ, Prentice-Hall.

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SCHMIDT, N.-H., EREK, K., KOLBE, L. M. & ZARNEKOW, R. Predictors of Green IT Adoption: Implications from an Empirical Investigation. Proceedings of the Sixteenth Americas Conference on Information Systems, 2010 Lima, Peru.

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Appendix B: Quality Assessment Form

1. Is this a research paper? Consider: - Is the paper based on research (or is it merely a "lessons l earned" report based on expert opinion?	☐ Yes	☐ No
2. Is there a clear statement of the aims of the research? Consider: - Is there a rationale for why the study was taken? - Is the study's focus or main focus on environmental sustainability? - Does the study relate to any category of conceptual, empirical, or design science study? - Is there a clear statement of the study's primary outcome?	☐ Yes	☐ No
3. Is there an adequate description of the context in which the research was carried out? Consider: - The nature of the organization which applied and adopted Green IT or Green IS - The types and initiatives of Green IT or Green IS deployed - The organization and context in which Green IT or Green IS used - The purpose of adoption of Green approach in the context	☐ Yes	☐ No

If question 1 or the questions 2 and 3 together received "No" as their answer, do not continue with the assessment.

4. Was the research design appropriate to address the aims of the research? Consider: - Has the researcher justified the research design (e.g. have they discussed how they decided which methods to use)?	☐ Yes	☐ No
5. Was the recruitment strategy appropriate to the aims of the research? Consider: - Has the researcher explained how the participants or cases were identified and selected? - Are the cases defined and described precisely? - Was the cases representative of a defined population? - Have the researchers explained why the participants or cases they selected were the most appropriate to provide access to the type of knowledge sought by the study? - Was the sample size sufficiently large?	☐ Yes	☐ No
6. Was there a control group with which to compare treatments? Consider: - How were the controls selected? - Were they representative of a defined population? - Was there anything special about the controls? - Was the no n-response high? Could non-respondents be different in any way?	☐ Yes	☐ No
7. Was the data collected in a way that addressed the research issue? Consider: - Were all measures clearly defined (e.g. unit and counting rules)? - Is it clear how data was collected (e.g. semi-structured interviews, focus group etc.)? - Has the researcher justified the methods that were chosen? - Has the researcher made the methods explicit (e.g. is there an indication of how interviews were conducted, did they use an interview guide)? - If the methods were modified during the study, has the researcher explained how and why? - Whether the form of the data is clear (e.g. tape recording g, video material, notes etc.) - Whether quality control methods were used to ensure completeness and accuracy of data collection	☐ Yes	☐ No

8. Was the data analysis sufficiently rigorous? Consider: - Was there an in-depth description of the analysis process? - If thematic analysis was used, is it clear how the categories/ themes were derived from the data? - Has sufficient data been presented to support the findings? - To what extent has contradictory data been taken into account? - Whether quality control methods were used to verify the results	☐ Yes	☐ No
9. Has the relationship between researcher and participants been considered adequately? Consider: - Did the researcher critically examine their own role, potential bias and influence during the formulation of research questions, sample recruitment, data collection, and analysis and selection of data for presentation? - How the researcher responded to events during the study and whether they considered the implications of any changes in the research design.	☐ Yes	☐ No
10. Is there a clear statement of findings? Consider: - Are the findings explicit (e.g. magnitude of effect)? - Has an adequate discussion of the evidence, both for and against the researcher's arguments, been demonstrated? - Has the researcher discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)? - Are limitations of the study discussed explicitly? - Are the findings discussed in relation to the original research questions? - Are the conclusions justified by the results?	☐ Yes	☐ No
11. Is the study of value for research or practice? - Does the researcher discuss the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or relevant research-based literature)? - Does the research identify new areas in which research is necessary? - Does the researcher discuss whether or how the findings can be transferred to other populations, or consider other ways in which the research can be used?	☐ Yes	☐ No

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